

ON THE UNDERGROUND PARTS OF TACCA PINNATIFIDA
J. R. & G. FORST. (1776) = TACCA LEONTOPETALOIDES
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With two plates

WHEN I undertook the preparation of the illustrations for Technical Manual 10-420¹ in the fall of 1942, naturally one of the species that I wished to include was the plant currently known as *Tacca pinnatifida* J. R. & G. Forst., the so-called Polynesian arrow-root. This is essentially a strand species in certain parts of the Old World tropics, and in former years it was an important source of food for the various native peoples inhabiting the vast area covered by its range. In earlier years it was actually cultivated by various peoples and in various localities all the way from India to Hawaii as well as in central Africa; as noted below, its present-day range in the Pacific region may be largely or perhaps wholly due to its ancient cultivation there. In modern times its actual cultivation has largely ceased. Its fairly large tubers are intensely bitter and are reported to be poisonous if eaten; yet the starch is easily extracted by maceration and washing, and, as finally prepared, it was utilized as food.

I turned to the published literature with confidence that I could locate a good illustration of its underground parts, for in excess of 25 pictures exist in botanical and horticultural literature. In this search I was disappointed. Being personally familiar with the plant, having seen it some thirty years ago as it occurs in nature, I knew what to expect, and yet when it came to preparing an illustration I did not dare to depend on my memory after the lapse of so many years. As a result, the drawing I had prepared for the Technical Manual depicts only those parts of the plant above the surface of the ground. Apparently in my years of tropical service I assumed, as others had done, that everything worthy of note regarding the underground parts of this striking species had been recorded in botanical literature, for many scores of descriptions have been published, to say nothing of the numerous illustrations. In all the literature examined I have found only two good descriptions of the underground parts, those of Rumphius in 1747 and Degener in 1932, but no really good illustrations.

It is indeed curious that good illustrations of the underground parts of this species apparently do not exist. In earlier years, in addition to its extensive cultivation here and there in the Old World tropics and the com-

¹ MERRILL, E. D. Emergency food plants and poisonous plants of the Islands of the Pacific. War Department, Technical Manual 10-420: 1-149. *f. 1-113*. 1943. Government Printing Office, Washington. Available from the Superintendent of Documents, price 15 cents.

mon utilization of its starch as food, it was commercially exploited in Polynesia, for the prepared starch, known as Tahiti arrow-root and as Polynesian arrow-root, was exported to Europe. In the middle of the last century large shipments are reported to have been made from Honolulu to San Francisco, particularly at the time of the gold rush to California in 1849-50.

In the special literature on economic plants there are numerous references to the actual cultivation of this *Tacca*, but today it apparently receives little attention. Dr. Harold St. John, of the University of Hawaii, informs me that it was formerly extensively cultivated in Hawaii, and that it was an important food plant. Some plantings were carefully attended, but in other places it was allowed to grow unattended in brush-lands adjacent to cultivated tracts. He notes that it is still cultivated by a few natives in the Kona District on the Island of Hawaii, but that its tubers are no longer shipped to Honolulu; further, that it also persists near the sites of former Hawaiian habitations on all the larger islands of the group. Being familiar with the plant as it occurs not only in Hawaii but also on Mehetia, Mangareva, Pitcairn, Rapa, Rurutu, Rotuma, and in Fiji, he is of the opinion that its occurrence and distribution in Polynesia are due to its tubers having been carried from one island to another by the early Polynesians, and he even suggests that it is a crop plant unknown in the wild.

This may be true for the Pacific islands, but it does not apply to those parts of Malaysia with which I am familiar. I believe that in the Malay Archipelago it is a native littoral species, and further, that its present-day distribution in Malaysia is probably due to its buoyant seeds having been floated here and there by ocean currents, assuming of course that they may retain their viability for some time while floating in salt-water. I base this belief on Guppy's observations as well as my own.

This belief is confirmed by the observations of Ridley,² who states, p. 318, that the plant grows in sand on the seashore and that its seeds have a spongy testa, by means of which they float for many months. He accounts for its wide distribution in central Africa (and this would apply to its occurrence in cultivation in parts of India) and perhaps to some extent for its abundance in the Polynesian islands by the utilization of its tubers as food, with the significant statement that: "In the intermediate area [i. e., Malaysia] it is rarely if ever used for food, and is not planted." Yet Rumphius notes the use of its starch for food in Amboina at the end of the sixteenth century, and Blanco, in 1837, states that the starch, known as *gaogao*, was sold in the Manila markets. Thus it may well have been cultivated here and there in the Malay Archipelago in earlier times.

In the Philippines one occasionally notes scattered plants in inland localities, but in such places the species is rare. However, on various small, isolated, and uninhabited islands — and such islands where I observed it are quite incapable of supporting human life, being unadapted to agricul-

² RIDLEY, H. N. Dispersal of plants throughout the world. i-xx. 1-744. *t.* 1-22. 1930.

tural pursuits — one frequently finds the species in abundance. On such islands it is found immediately back of the seashore, in deep sand heavily charged with comminuted vegetable debris, well above high-tide mark, in the partial shade of beach thickets and forests, but yet where the sand is at times disturbed by wave action. This observation as to its natural habitat being near the seashore conforms with those of others, notably Rumphius, who for this particular species selected the name *litorea* because of its characteristic habitat. On such islands as above noted I never observed it inland from the seashore. Guppy,³ in contrasting *Tacca pinnatifida* with another species, states that the seeds of *Tacca pinnatifida* float for months, and that they owe their buoyancy to the spongy tissue developed in their seed-coverings. Unfortunately, he did not determine how long the seeds floating in salt-water retained their viability; this, as with the seeds of such species as *Hibiscus tiliaceus* Linn. and other widespread strand plants, would seem to be a desirability.

Here is apparently a species native of certain littoral parts of the Malay Archipelago and distributed through natural means throughout that region and perhaps to littoral regions of southern Asia, but which has further been distributed by man in various parts of India, especially inland, and to the wide stretches of the Pacific Ocean. However, the objective of this short paper is to discuss the underground parts of the plant, rather than its origin and how it was distributed. Whatever the method or methods of distribution, its present range extends from India and Ceylon to Indo-China and Formosa, southward through Malaysia to the northern parts of Australia and New Caledonia, and throughout the Pacific region as far east as Hawaii and the Marquesas Islands. It is suspected that the African material referred by Limpricht to another species actually represents the one here discussed.

In checking the numerous listed illustrations, I note that the first published one, that of Ammann in 1741, does show two tubers, but here possibly because the artist may have superimposed the basal parts of two plants, one in flower and one in fruit (*Plate 2, f. A*). This first published picture of the underground parts is the best one yet issued in that possibly it does depict the original tuber and the new primary tuber terminating a short rhizome.

In the horticultural literature, generally speaking, only those parts of the plant above ground are shown, the various authors who published colored plates prepared from living specimens apparently having been interested only in the ornamental aspects of the plant. A few botanical illustrations do show the beginning of the development of the specialized tuber-bearing rhizomes. Curiously, several of the modern illustrations go back to Rumphius (1747), sometimes as to the habit, more frequently as to the underground parts, which are not too well depicted, although excellently

³ GUPPY, H. B. Observations of a naturalist in the Pacific between 1896 and 1899, 2: 19. 1906. (Plant dispersal).

described by him. In the recent standard monographic treatment⁴ of 1928, the only illustration of this very common and widely distributed species was taken wholly from Rumphius. This is *Tacca litorea* Rumph. Herb. Amb. 5: 328. t. 114. 1747. The illustration was prepared about 1690, although not published until 1747; this figure shows only a somewhat deformed and shrunken old tuber (*Plate 1, f. A*) from which the plant had developed, but neither the characteristic rhizomes nor the equally characteristic new tubers that are produced at the ends of the rhizomes and at some distance from the base of the plant. Lamarck's misleading illustration of 1793 was clearly drawn from an herbarium specimen (*Plate 1, f. B*) and is very unsatisfactory. Dubard, Agr. Prat. Pays Chauds 11: 106. f. 38. 1911 (*Plate 1, f. E*), illustrates the vegetative parts as springing from a depressed-globose tuber which bears a couple of incipient rhizomes but no secondary tubers. Sadebeck, Die Kulturgewächse der deutschen Kolonien und ihre Erzeugnisse, f. 31. 1899, depicts the initial tuber but without rhizomes or secondary tubers (*Plate 1, f. C*). Degener, Fl. Hawaiiensis 2: t. [11]. 1932, while giving one of the best descriptions of the underground parts that I have seen (*Tacca hawaiiensis* Limpr. = *T. pinnatifida* J. R. & G. Forst. = *T. Leontopetaloides* (Linn.) O. Kuntze), provides an excellent habit sketch of the plant but without even a vestige of the old tuber, although his illustration does depict a couple of incipient rhizomes (*Plate 1, f. D*). His description of the underground parts is so good that it is here reproduced:

"Glabrous herb with depressed-globose light yellowish brown about 5 cm. high and 8 cm. wide thin-skinned smooth tuber near surface of ground . . . which is replaced during the year by a new main tuber which arises from a downward-growing thick rhizome at a lower level and remains dormant after yearly death of aerial parts of plant; secondary smaller tubers also forming from buds above old tuber and spreading downward; tubers white within, starchy, somewhat juicy; roots arising from top of old tuber, spreading. . . ."

But this is not the only good published description, for that of Rumphius, written toward the close of the seventeenth century but not published until 1747, is actually as good. The Latin version of this old description is: "Radices ejus panem referunt, magnitudine binorum pugnorum, immo majores, nudae & gilva obductae pellicula, interne albae, & succosae, atque ex superiore ipsarum parte multae dependent fibrillae, undique autem ad latera modi excrescunt, ex quibus novi propullulant surculi. Primaria vero radix directe cauli obposita saepe haud major est minore pugno, bulbosa, ac sine gemmis, ad binorum vero digitorum spatium supra hanc e stipite crassus excrescit caulis, deorsum flexus, e quo similis dependet radix, seu bulbus, plerumque major primaria radice." His original Dutch version is equally good and explicit: "De worteln zyn broodjes in de groote van twee vuisten of meer, buiten kaal, en met een vaal buideken omgeven, binnen wit, en zappig, van boven hangen 'er veele Vaselingen, rondom ter

⁴ LIMPRICHT, W. Taccaceae. Pflanzenreich 92(IV. 42): 1-32. f. 1-5. 1928.

zyden komen knobbeln voort, waar uit nieuwe spruitjes worden. De principaale wortel regt over den stam staande is dikwils niet grooter dan een kleene vuist, bultig, en zonder afzetzel, maar twee vingers boven de zelve komt uit den stam een dikken steel neerwaarts, daar aan een diergelyke wortel of bol hangt, gemeenlyk grooter dan de principaale."

Clearly Rumphius excavated the underground parts carefully, noting the characteristic downward-growing rhizomes produced from the stem just above the old tuber, that a new tuber was formed at the end of each rhizome, and further that the new main tuber was larger than the original one. I have reproduced these two old descriptions in extenso, for they conform to Degener's modern one quoted above. That Rumphius did not depict the underground parts as he described them should not be charged against him, when it is understood that his original illustrations were destroyed by fire, and that the new ones that were used to illustrate his *Herbarium Amboinense* were prepared by others after he had become blind. Clearly what one observes regarding the underground parts of this very characteristic and striking species depends on how carefully the tubers are dug and at what stage in the development of the plant the excavating was done. One might find, shortly after the vegetative parts appear, only a normal tuber; later this tuber would be more or less deformed and shrunken; still later the new rhizomes would be evident; and finally, if the underground parts be examined after the vegetative parts have reached full maturity or have disappeared, the original tuber would be found to have been more or less absorbed, and the new main tuber even larger than the original one, with a varying number, never very numerous, of smaller tubers which at the next growing season would produce small plants; these new tubers, large and small, are solitary and each terminates a simple rhizome.

Tubers that I examined many years ago in the Philippines varied from about five to about seven or eight centimeters in greatest diameter, varying in shape from globose to broadly ellipsoid. The new ones occurred in the loose sandy soil some distance from the base of the old plant and sometimes as much as ten inches below the surface of the soil. Dubard, l. c., notes that, according to the soil conditions, the new tubers may be as much as a foot from the base of the plant. Wohltmann⁵ reproduced a photograph of somewhat dessicated tubers originating in Samoa, the largest being about 10 cm. in diameter, stating: "Das unterirdische, bisweilen kriechende Rhizom entwickelt Achselsprosse, welche sich zu mit dichtem Stärkemehl angefüllten Knollen verdicken." Mr. W. Greenwood, of Lautoka, Fiji, who kindly sent me some dried material, states that the tubers in Fiji are about five by seven centimeters as he has observed them; two of these small tubers from a very young plant are shown (*Plate 1, f. I, K*). The plants, being juvenile, were not more than about a foot high, and the characteristic rhizomes and secondary tubers had not commenced to form except in one case, among the several examined. I am also indebted to Mr. E. Y.

⁵ WOHLTMANN, F. *Tacca pinnatifida*, die stärkemehlreichste Knollenfrucht der Erde. *Tropenpflanz.* 9: 120-128. f. 103. 1905.

Hosaka, of Honolulu, for his courtesy in sending me fresh tubers for greenhouse culture. Unfortunately these did not produce new plants, and so it was impossible for me to have any tests made with the view of determining the poisonous principle involved. That they are poisonous when fresh is unquestionably true, for Dr. St. John informs me that on Mehetia Island he took a small bite of a tuber, then spat it out immediately. It burned his tongue worse than *Colocasia*, was disagreeable and nauseating, making him half-sick for the rest of the forenoon. He calls my attention to E. M. Loeb's quotation of a native saying on Niue Island, Bishop Mus. Bull. 32: 103. 1926: "The pia [*Tacca*] is the most poisonous of all plants since all the animals who eat of this bush are sure to die." It is reported to be very bitter, and one author who examined the starch noted the presence of raphides.

Dr. St. John could not, because of restrictions on travel due to war conditions, examine living plants, but he did kindly send me several sketches of the underground parts, these prepared by Miss Marie Neal, of the Bishop Museum, one from herbarium specimens, the others from preserved material. These figures are here reproduced (*Plate 1, f. F, G, H, J*).

While in the title of this paper I have, for obvious reasons, given the almost universally used Latin binomial of this plant, I have also noted that the oldest valid name for the species is *Tacca Leontopetaloides* (Linn.) O. Kuntze, Rev. Gen. Pl. 704. 1891, its basis being *Leontice Leontopetaloides* Linn. Sp. Pl. 313. 1753, which in turn was based wholly on Amman[n]'s description and illustrations of *Leontopetaloides* Amman[n], Comment. Acad. Sci. Imp. Petropol. 8: 211. *t. 13* [and *t. 13 bis*], 1741. Both of Ammann's original illustrations are reproduced herewith (*Plate 2, f. A, B*). This has been done for two reasons, first because the Ammann paper is not very generally available in the libraries of botanical institutions, and second to point up the obvious fact that the Linnaean specific name is the one that Limpricht should have used in a modern monograph that otherwise follows the provisions of the International Code of Botanical Nomenclature; there is no conserved list of specific names. He cites in the synonymy of *Tacca pinnatifida* J. R. & G. Forst. (1776) not only *Leontice Leontopetaloides* Linn. and *Tacca Leontopetaloides* O. Kuntze, but also the original Ammann illustration on which both of these binomials were wholly based. Limpricht states that the tubers are "permagna (saepe mole capitis infantis)," this apparently having been taken from Roxburgh, Fl. Ind. ed. 2, 2: 172. 1832, who says: "Root tuberous, perennial, often as large as a child's head, round, and pretty smooth." The latter author had living specimens in the Calcutta Botanic Garden, the species having been introduced from Malaya in 1800. Hooker f., Fl. Brit. Ind. 6: 287. 1892, was somewhat cautious, as he says: "*Rootstock* globose, 1 ft. diam. under cultivation." Rumphius says that the tubers are as large as one's two fists or larger. Although I have never seen tubers of the wild form more than about 8 cm. in largest diameter, it is highly probable that they reach sizes considerably larger than this, at least in cultivation. Burkill, Dict. Econ.

Prod. Malay Peninsula 2: 2118. 1935, states that the tubers sometimes weigh about two pounds, while Heyne, Nuttige Pl. Nederl. Ind. ed. 2, 1: 453. 1927, sub *Tacca Leontopetaloides* (Linn.) O. Kuntze, mentions material from the Anambas Islands, where the tubers were reported to be as large as a coconut; if by this comparison an unhusked coconut was intended, one would suspect that the observer may have confused the large corms of *Amorphophallus campanulatus* Blume with the tubers of *Tacca*. No less acute an observer than Rumphius did this when he described and illustrated what is clearly an *Amorphophallus* as *Tacca sativa* Rumph., Herb. Amb. 5: 324. t. 112. 1747, and following this *Tacca phallifera* Rumph. op. cit. 326. t. 113; in the latter the vegetative parts and fruits are clearly those of *Tacca pinnatifida* J. R. & G. Forst. = *T. Leontopetaloides* (Linn.) O. Kuntze, but the detached inflorescence, f. 2, indicated in the explanation of the plate as "*Figura Secunda Phallum ipsum, seu Taccae fungum denotat*," is clearly a representation of the spathe and spadix of an *Amorphophallus*, of the Araceae.

To the generally accepted synonyms, *Tacca pinnatifida* Gaertn. (1788), *T. dubia* Spreng. (1829), *T. Gaogao* Blanco (1837), and *T. oceanica* Nutt. (1838), may be added *T. hawaiiensis* Limpr. f. (1928), for I agree with Dr. St. John's opinion, as expressed by him, *in lit.*, that the latter supposedly distinct species is but a small form of the ubiquitous *Tacca pinnatifida* J. R. & G. Forst. = *T. Leontopetaloides* (Linn.) O. Kuntze. On the basis of such material as has been available to me for study, I find Limpricht's recent monographic treatment unsatisfactory. While most authors refer the African material to *Tacca pinnatifida* J. R. & G. Forst., Limpricht does not admit its occurrence in Africa, but places such material under *Tacca madagascariensis* Boj. and *T. involucrata* Schum. & Thonn. One suspects that he placed too much confidence in variable characters, and that as with *T. hawaiiensis* Limpr. certain other reductions are indicated. To be noted in this connection is Exell's recent critical Catalogue of the Vascular Plants of S. Tomé (1944), where (p. 344) he accepts the binomial *Tacca Leontopetaloides* (Linn.) O. Kuntze and, on the authority of Durand & Schinz, credits the species to S. Tomé, an island in the Gulf of Guinea near the west coast of Africa.

Some might argue from Ammann's illustration, which apparently attempts to indicate a maculate stem (although this character is not mentioned in his description), that something other than this common *Tacca* might have been the basis of his *Leontopetaloides*. Certainly in 1741 he could have had nothing from the range of *Tacca maculata* Seem. (Fiji, Samoa, northern Australia); all he says as to locality is "India Orientalia," and this might mean from any part of the Indo-Malaysian region. His description of the stems is: "Caules . . . praealti, teretes, cineracei, striis nigricantibus creberrimis notati, digiti minoris crassitie"; and the striking longitudinally striate stem is very characteristic of the widespread species here discussed.

After all, this note is perhaps a pointed commentary on how little atten-

tion many collectors in the field give to the underground parts of plants that they collect. The situation a few centuries ago is in sharp contrast to this, for then, because of the medicinal or other economic uses of the underground parts of plants, those concerned with preparing illustrations of plants generally gave very special attention to roots, tubers, bulbs, rhizomes, and corms, that are normally not shown at all well by ordinary herbarium specimens.

EXPLANATION OF PLATES

PLATE I

Underground parts of *Tacca Leontopetaloides* (Linn.) O. Kuntze (*T. pinnatifida* J. R. & G. Forst.). FIG. A. The tuber after Rumphius (1747). FIG. B. The tuber after Lamarck (1793). FIG. C. The tuber as depicted by Sadebeck (1899). FIG. D. No old tuber shown but incipient rhizomes are indicated, Degener (1932). FIG. E. The initial tuber and two incipient rhizomes as depicted by Dubard (1911). FIGS. F, G, H, J. Redrawn from sketches made by Miss Marie Neal, Bishop Museum, Honolulu, all from preserved material except F, which was taken from a herbarium specimen; of these G depicts the remnants of the initial tuber and two rhizomes, one of these bearing a partly grown secondary tuber, and H, a mature tuber as detached from the end of a rhizome. FIGS. I, K. Young tubers from juvenile Fijian plants, one showing the beginning of a rhizome, the last two natural size.

PLATE II

FIGS. A, B. The original illustrations of *Leontopetaloides*, Amman[n] Comment. Acad. Sci. Petrop. 8: *t.* 13. 1741. This is the entire basis of *Leontice Leontopetaloides* Linn. Sp. Pl. 313. 1753, and hence of *Tacca Leontopetaloides* (Linn.) O. Kuntze. Both Linnaeus and Limpricht cite the plate as 113. There are two plates, both indicated as "Tab. XIII," the first showing the habit of the entire plant, including the underground parts, the second a part of a leaf, the inflorescence, fruits and flowers, and the tuber (detached), natural size. Incidentally the underground parts are depicted on the plate showing the habit of the entire plant more nearly as they actually are than in any hitherto published illustrations that I have seen. Reduced about $\frac{1}{2}$.

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